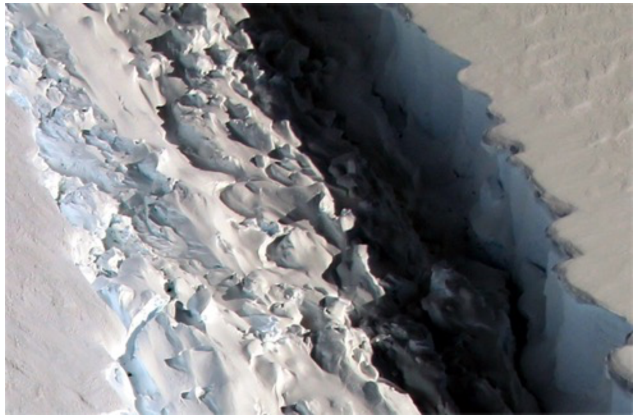
SCIENCE



Surface Biology and Geology Designated Observable

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California Institute of Technology
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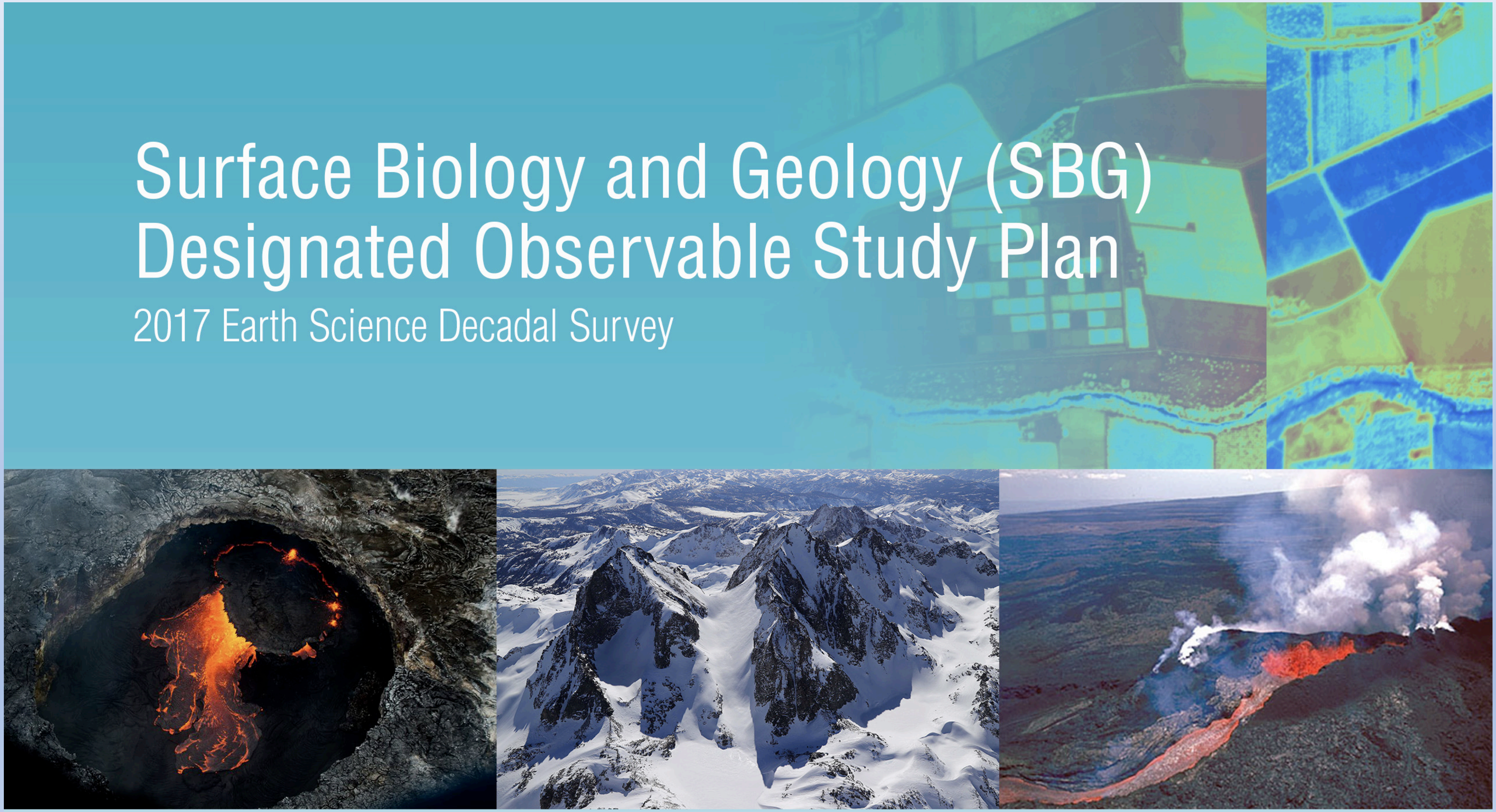
SBG Study Unites Diverse Priorities & Communities

- The 2017 ESAS directed SBG to integrate across E, S, H, W, C, A and between TIR and VSWIR
- We have integrated the FAs in leadership and within working groups focused on problems faced by the all FAs
  - We have NOT emphasized FA breakouts
- Study objectives and measurement targets are taken from the ESAS report to the greatest extent possible
  - Atmospheric Correction and other key technical omissions added
- Diverse FAs often have allied needs
- Formulation looks for "sweet spots" and synergy across FAs and with other DOs

The goal is an Architecture that delivers >70% solutions across all FAs rather than a 100% solution in 1 FA

HQ Directives Were Captured in the SBG Study Plan



Directives at kick-off meeting: key phrases…

- Transparent,
- Open,
- Inclusive,
- Explore options,
- New start, not reboot,---
- Observing systems rather than missions,
- Objectives and measurement targets **not** requirements,
- Think outside the box
- This isn’t HyspIRI

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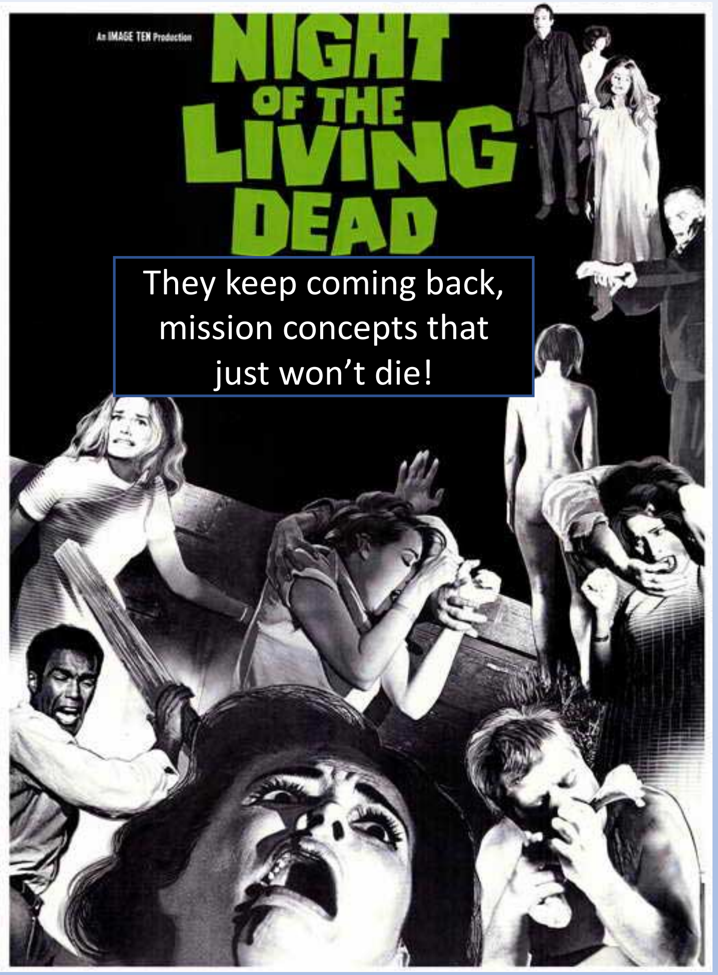
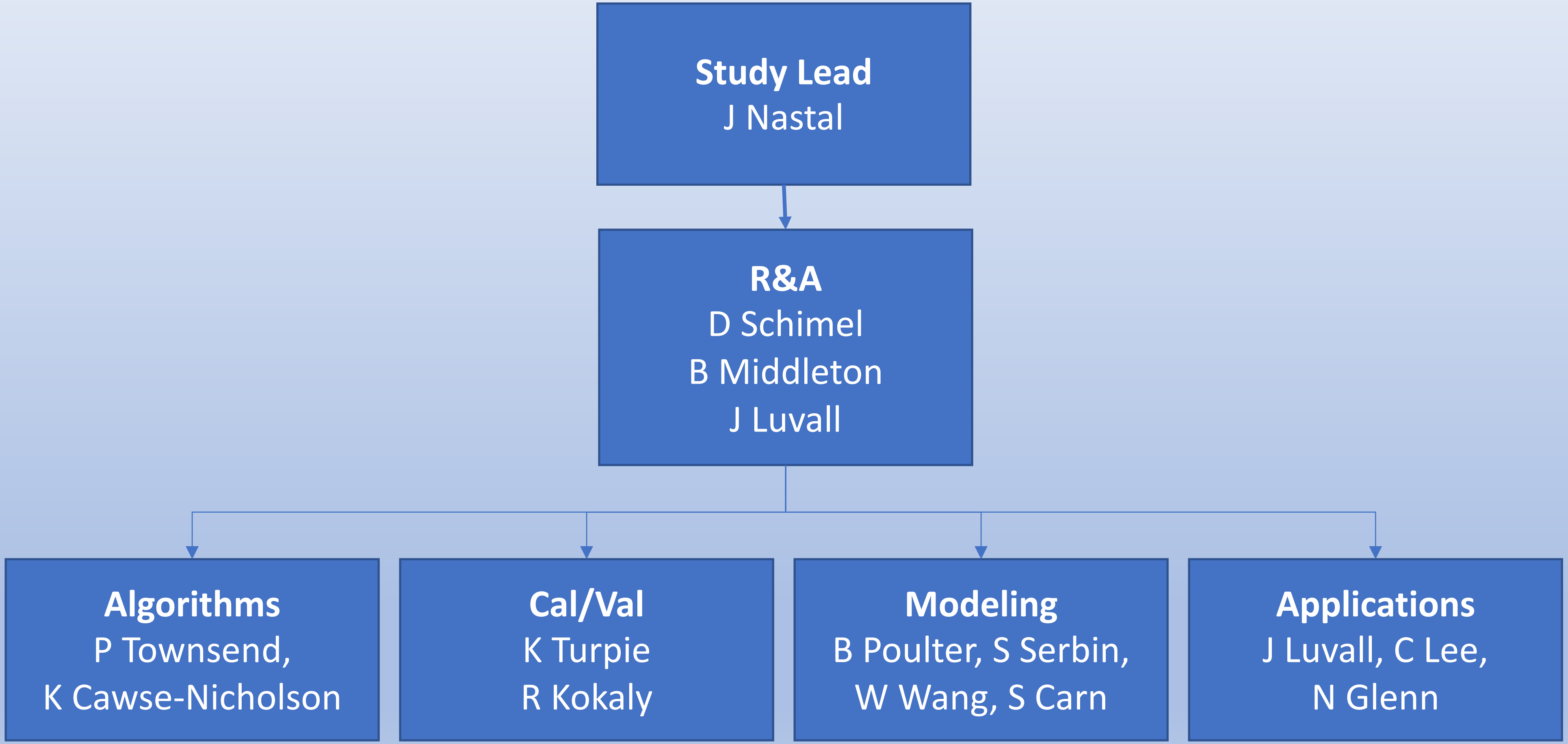


Preparing for the Future Now: Engage a New Generation of SBG Scientists

Don’t wait for SBG launch - PREPARE NOW! Launch is soon, in career terms, and there’s a learning curve. EOS taught us the benefits of early engagement

- Create a vibrant community ready to exploit SBG data at launch,
- Early recruitment of diverse, Early Career scientists ready to build careers on SBG
- Involve your students and post-docs NOW,
- Adopt-a-colleague, walk down the hall and talk to an avian community ecologist, geomorphologist, urban planner, agricultural extension specialist and convey to them the new opportunities from new observables, invite one of the team for a seminar….
- Our process is exceptionally open…
- NASA centers are already advertising SBG-linked post-docs: have your students follow the announcements of opportunity.

SBG Organized R&A Activities By Working Groups



SBG R&A Working Groups Are Responsible for Essential Study Deliverables

- **Algorithms:** list of mandated (ESAS) and significance data products, algorithm maturity, dependencies, end-to-end workflow
  - >100 participants
- **Cal/val:** pre-launch, on-orbit-input to architecture, vicarious, stability and traceability
  - >100 participants
- **Modeling:** end-to-end quantitative traceability for value framework, assessment of model maturity for SBG
  - >70 participants
- **Applications:** responsible for the Community Assessment Report as well as inputs to architecture (latency, direct broadcast, onboard quick look), as well as early adopter plan, **inputs to SATM**
  - >200 participants
- This meeting (>100 participants on site + webex)
- RFI-just released

SBG Community Is Active, Energized and Eager for Global VSWIR/TIR Imagery

- More than 400 people engaged in SBG WGs
- Nearly 200 people at this meeting
- More than 100 NOIs submitted to ECOSTRESS Science Team call

SBG: One TEAM, Diverse Science & Applications

- Ecosystems (E)
  - Terrestrial
  - Coast and inland
- Hydrology (H)
  - Snow
  - Evapotranspiration
- Solid Earth (S)
- Weather (W)
- Climate (C)
- Applications (A): all Focus Areas

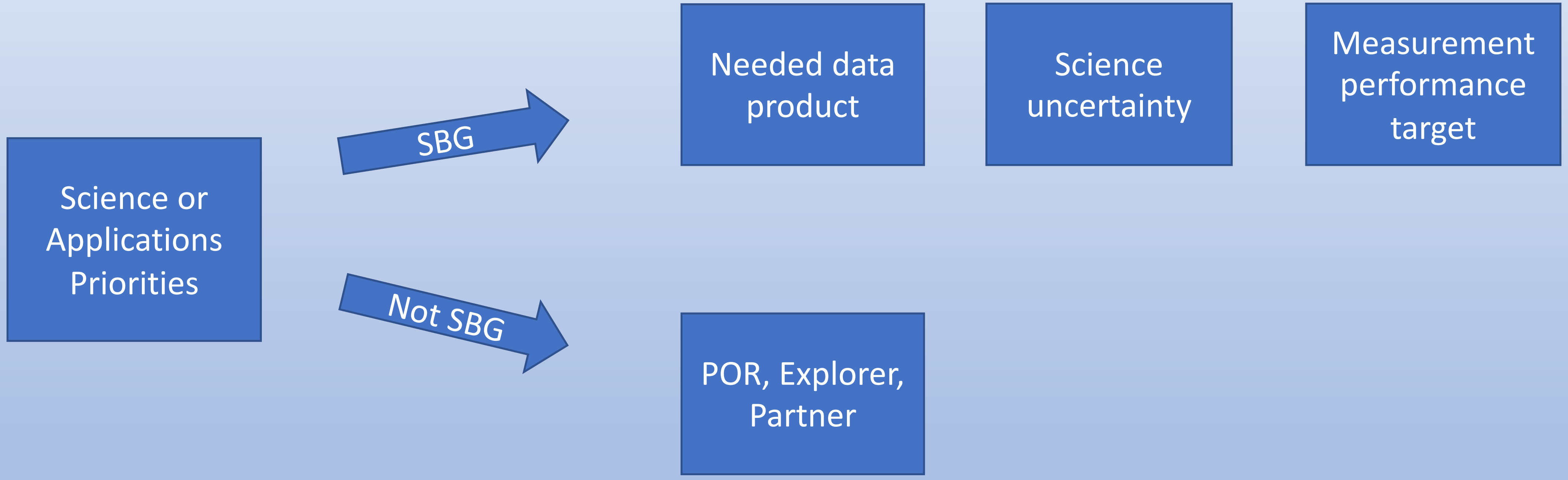
Most Important Priorities

Priority ID	Panel	Description
Most Important Objectives		
E1c	Ecosystems	Quantify the physiological dynamics of terrestrial and aquatic primary producers.
E2a		Quantify the fluxes of CO_2 and CH_4 globally at spatial scales of 100 to 500 km and monthly temporal resolution with uncertainty <25% between land ecosystems and atmosphere and between ocean ecosystems and atmosphere.
E3a		Quantify the flows of energy, carbon, water, nutrients, etc. sustaining the life cycle of terrestrial and marine ecosystems and partitioning into functional types.
H1c	Hydrology	Quantify rates of snow accumulation, snowmelt, ice melt, and sublimation from snow and ice worldwide at scales driven by topographic variability.
S1a	Solid Earth	Measure the pre-, syn-, and post-eruption surface deformation and products of Earth’s entire active land volcano inventory at a time scale of days to weeks.

Very Important Priorities

Very Important Objectives		
E1a	Ecosystems	Quantify the distribution of the functional traits, functional types, and composition of vegetation and marine biomass, spatially and over time.
H2a	Hydrology	Quantify how changes in land use, water use, and water storage affect evapotranspiration rates, and how these in turn affect local and regional precipitation systems, groundwater recharge, temperature extremes, and carbon cycling.
H4a		Monitor and understand hazard response in rugged terrain and land margins to heavy rainfall, temperature and evaporation extremes, and strong winds at multiple temporal and spatial scales. This socioeconomic priority depends on success of addressing H-1b and H-1c, H-2a, and H-2c.
S1c	Solid Earth	Forecast and monitor landslides, especially those near population centers.
S2b		Assess surface deformation (<10 mm), extent of surface change (<100 m spatial resolution) and atmospheric contamination, and the composition and temperature of volcanic products following a volcanic eruption (hourly to daily temporal sampling).
C3a	Climate	Quantify CO_2 fluxes at spatial scales of 100-500 km and monthly temporal resolution with uncertainty <25% to enable regional-scale process attribution explaining year-to-year variability by net uptake of carbon by terrestrial ecosystems (i.e., determine how much carbon uptake results from processes such as CO_2 and nitrogen fertilization, forest regrowth, and changing ecosystem demography.)
W3a	Weather	Determine how spatial variability in surface characteristics modifies regional cycles of energy, water and momentum (stress) to an accuracy of 10 W/m^2 in the enthalpy flux, and 0.1 N/m^2 in stress, and observe total precipitation to an average accuracy of 15% over oceans and/or 25% over land and ice surfaces averaged over a 100 × 100 km region and 2- to 3-day time period.

Priorities inform traceability traceability flows through data products



Priorities to Data Products CC&E-Terrestrial

M/V priorities for TE	Data products	Measurement source
Quantify the global distribution of the functional traits, functional types, and composition of vegetation spatially and over time.	Plant functional traits Plant functional types Species or PFT distribution	SBG VSWIR
Quantify the physiological dynamics of terrestrial and aquatic primary producers	Plant functional traits Plant functional types Species or PFT distributions and change	SBG VSWIR
	Evapotranspiration	SBG TIR SBG VNIR
	Photosynthesis Respiration	POR or Explorer
Quantify the fluxes of CO_2 and CH_4 globally at spatial scales of 100-500 km and monthly temporal resolution with uncertainty < 25% between land ecosystems and atmosphere and between ocean ecosystems and atmosphere.	Plant functional traits Plant functional types Species or PFT distributions and change	SBG VSWIR
	Biomass Net CO2 flux Photosynthesis Respiration Biomass burning CH4 flux	POR or Explorer

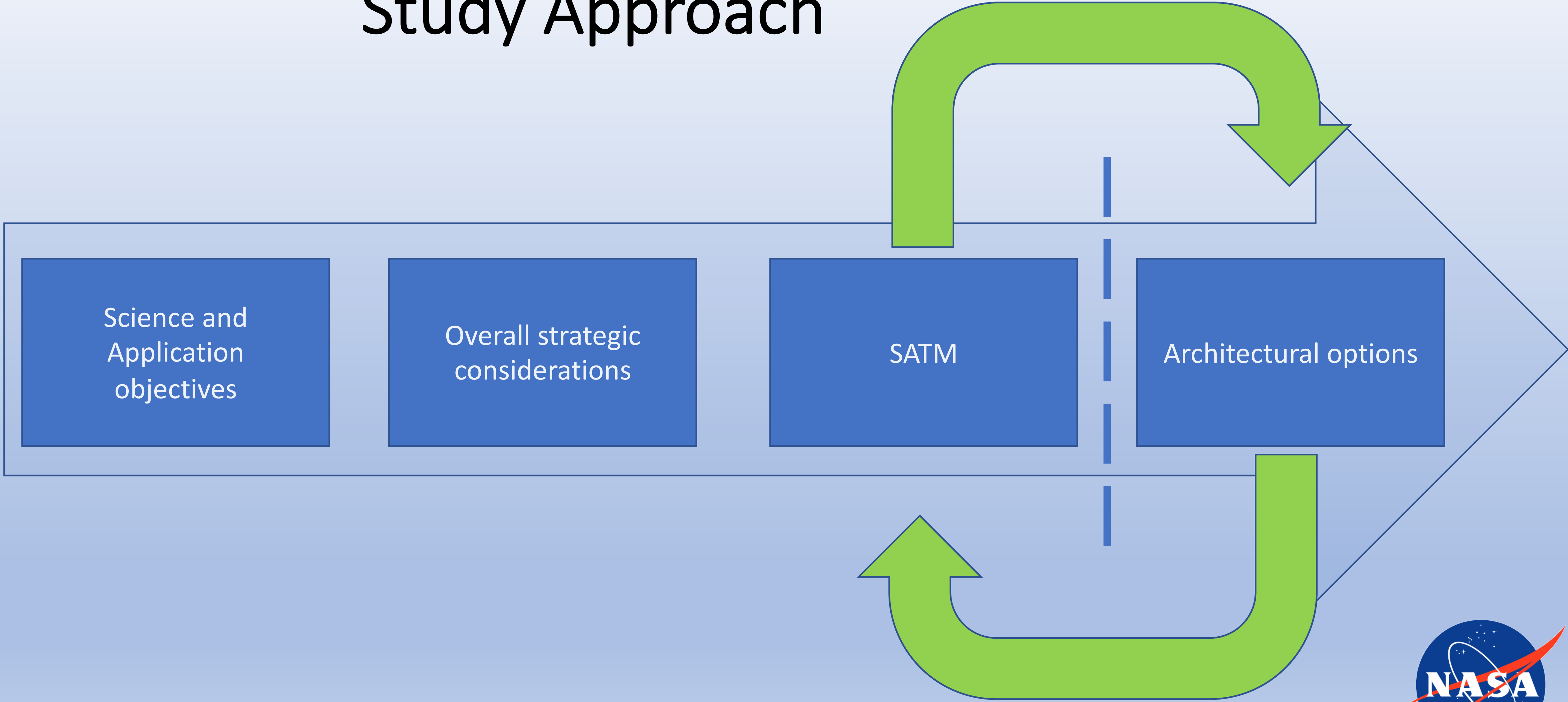
Solid Earth

M/V priorities for ES&I	Data products	Measurement source
S1a - Measure the pre-, syn-, and post-eruption surface deformation and products of Earth's entire active land volcano inventory at a time scale of days to weeks.	Land surface temperature during eruptions (high temperature range) Fractional coverage of eruption products (flows & deposits) Gas and aerosol concentrations and fluxes	SBG VSWIR, SBG TIR
	Land surface temperature before & after eruptions Silicate composition of eruption products (flows & deposits)	SBG TIR
S2b - Assess surface deformation (<10 mm), extent of surface change (<100 m spatial resolution) and atmospheric contamination, and the composition and temperature of volcanic products following a volcanic eruption (hourly to daily temporal sampling).	Changes in land surface composition and temperature	SBG VSWIR, SBG TIR
S1c - Forecast and monitor landslides, especially those near population centers.	Vegetation cover and composition Substrate composition	SBG VSWIR, SBG TIR
	Soil moisture Soil temperature	SBG TIR and POR

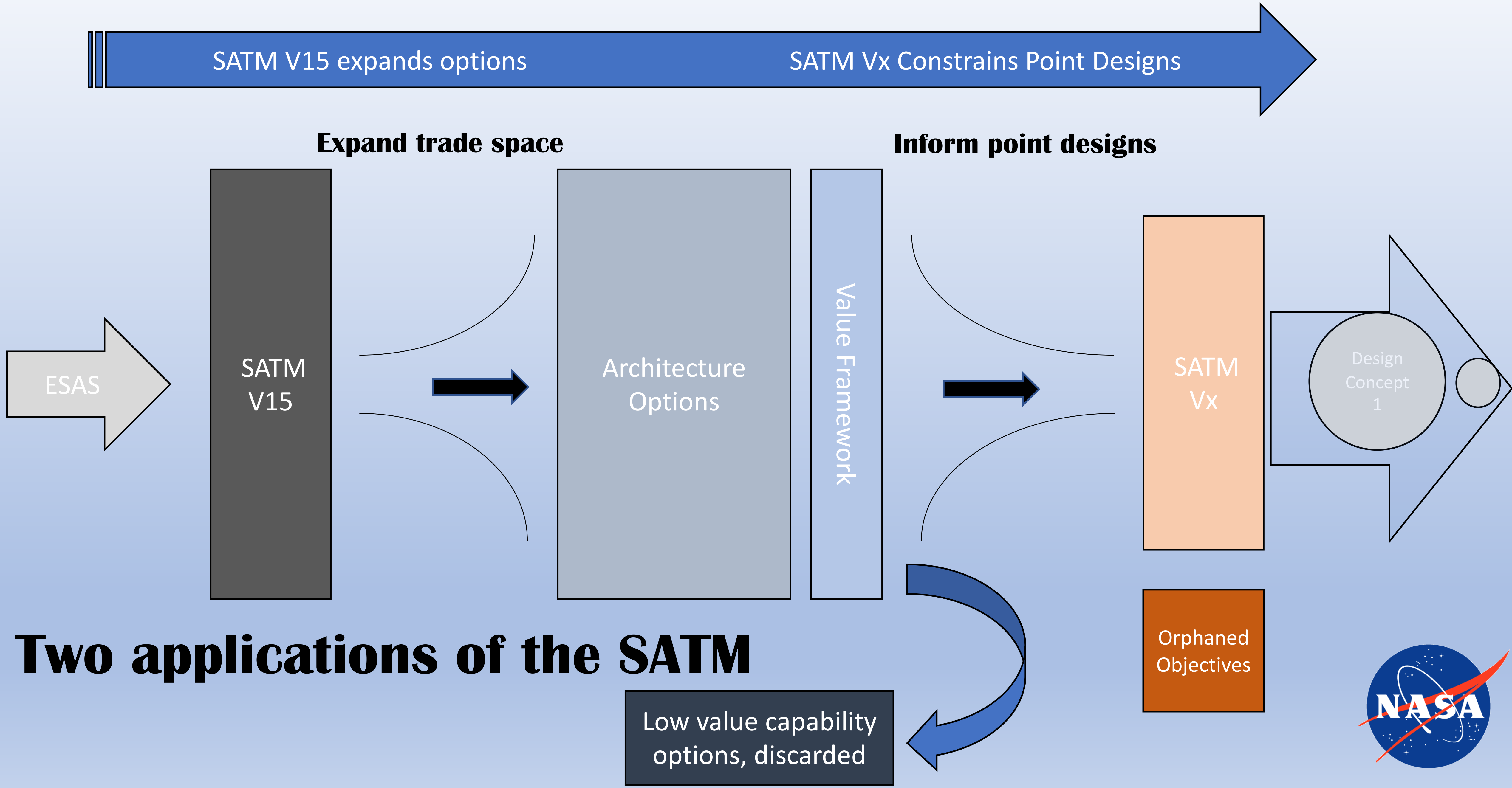
Weather

M/V priorities for Weather	Data products	Measurement source
Determine how spatial variability in surface characteristics modifies regional cycles of energy, water and momentum (stress) to an accuracy of 10 W/m2 in the enthalpy flux, and 0.1 N/m2 in stress, and observe total precipitation to an average accuracy of 15% over oceans and/or 25% over land and ice surfaces averaged over a 100 × 100 km region and 2- to 3-day time period	Evapotranspiration	SBG VSWIR SBG TIR
	Albedo	SBG VSWIR
	Snow cover	SBG VNIR
	Vegetated cover (plant functional type, canopy height)	SBG VSWIR POR (Lidar or radar)

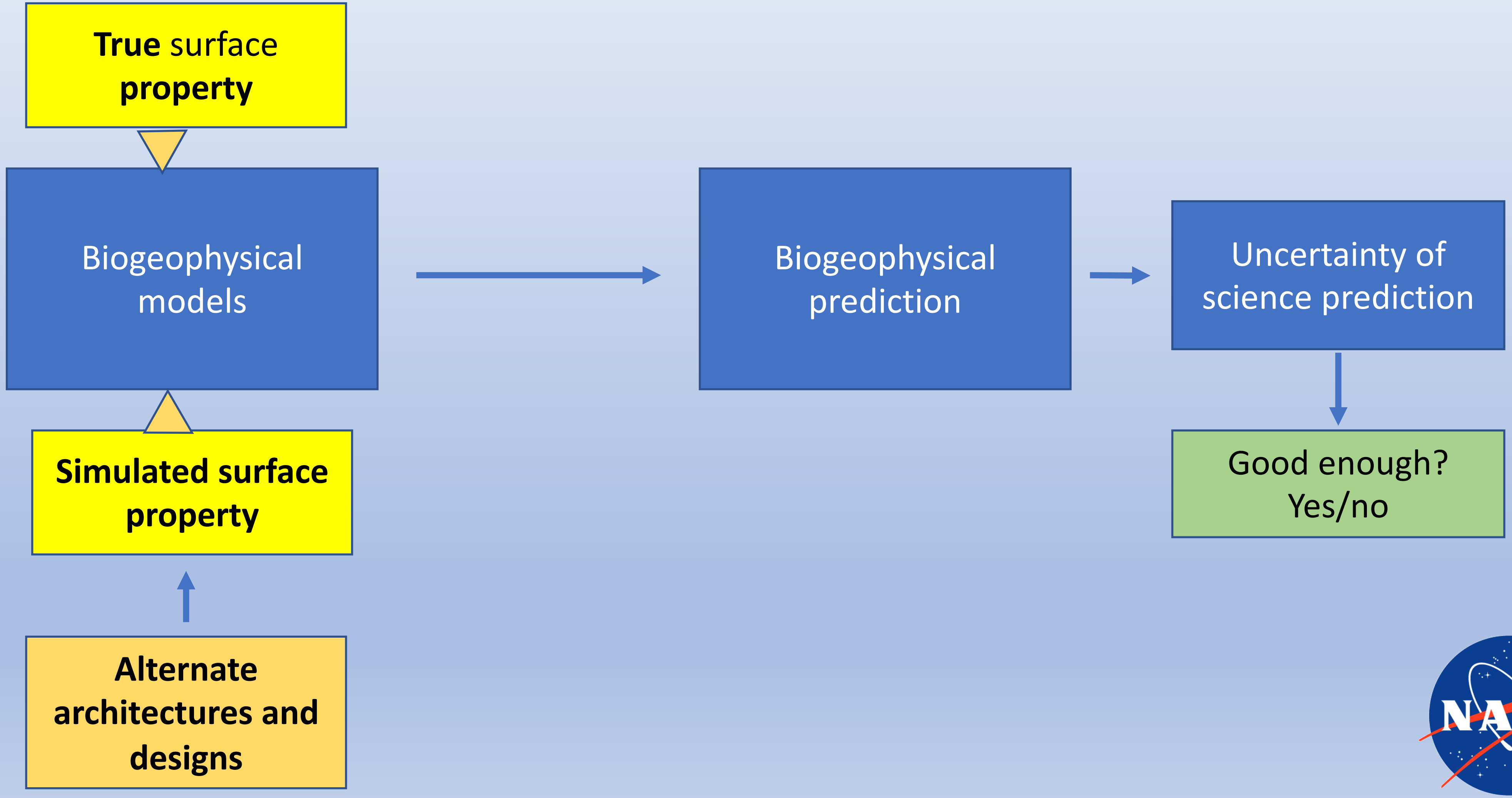
Study Approach



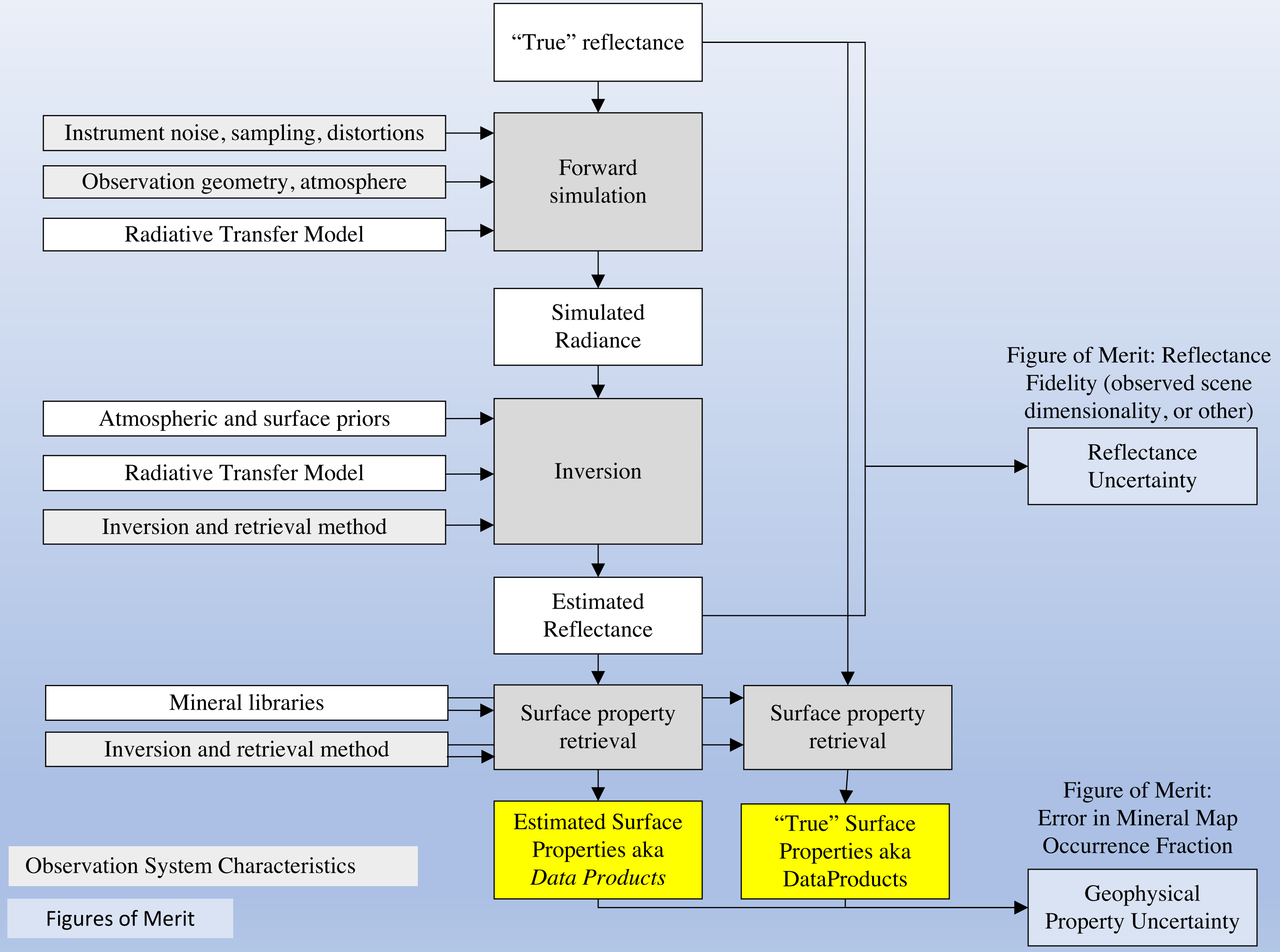
Two applications of the SATM



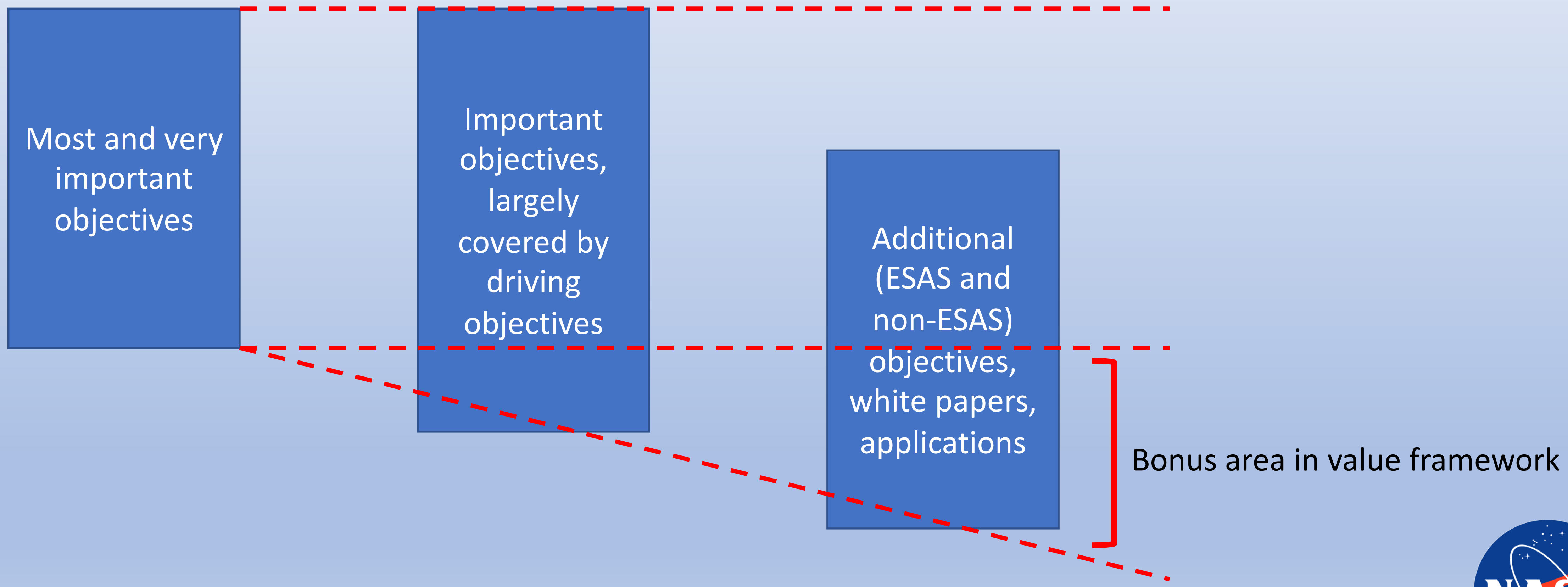
Science uncertainty from OSSEs



Quantitative Traceability Approach



Bonus Points for meeting important and applications objectives



ESAS "Themes"

- GLOBAL
- CHANGE, implies duration, stability
- EVENTS
- No clear distinction between "research" and "applications" in ESAS report

Science data product classes

- Plant traits
- Evapotranspiration
- Minerals
- Aquatic biology
- Snow cover and albedo
- Fire
- Volcanic gases
- Natural Hazards (Landslides, lava, fire, oil spills, urban emergency)
- *Atmospheric correction*

Science data product classes and dominant driving objectives

• Plant traits	Spectral performance
• Evapotranspiration	Temperature versus emissivity, frequency
• Minerals	Spectral performance
• Aquatic biology/biogeochemistry	Spectral performance, frequency
• Snow cover and albedo	Frequency
• Fire	Frequency, 4 micron dynamic range
• Volcanic gases	Frequency
• Natural Hazards	Frequency
• Atmospheric Correction	Spectral performance

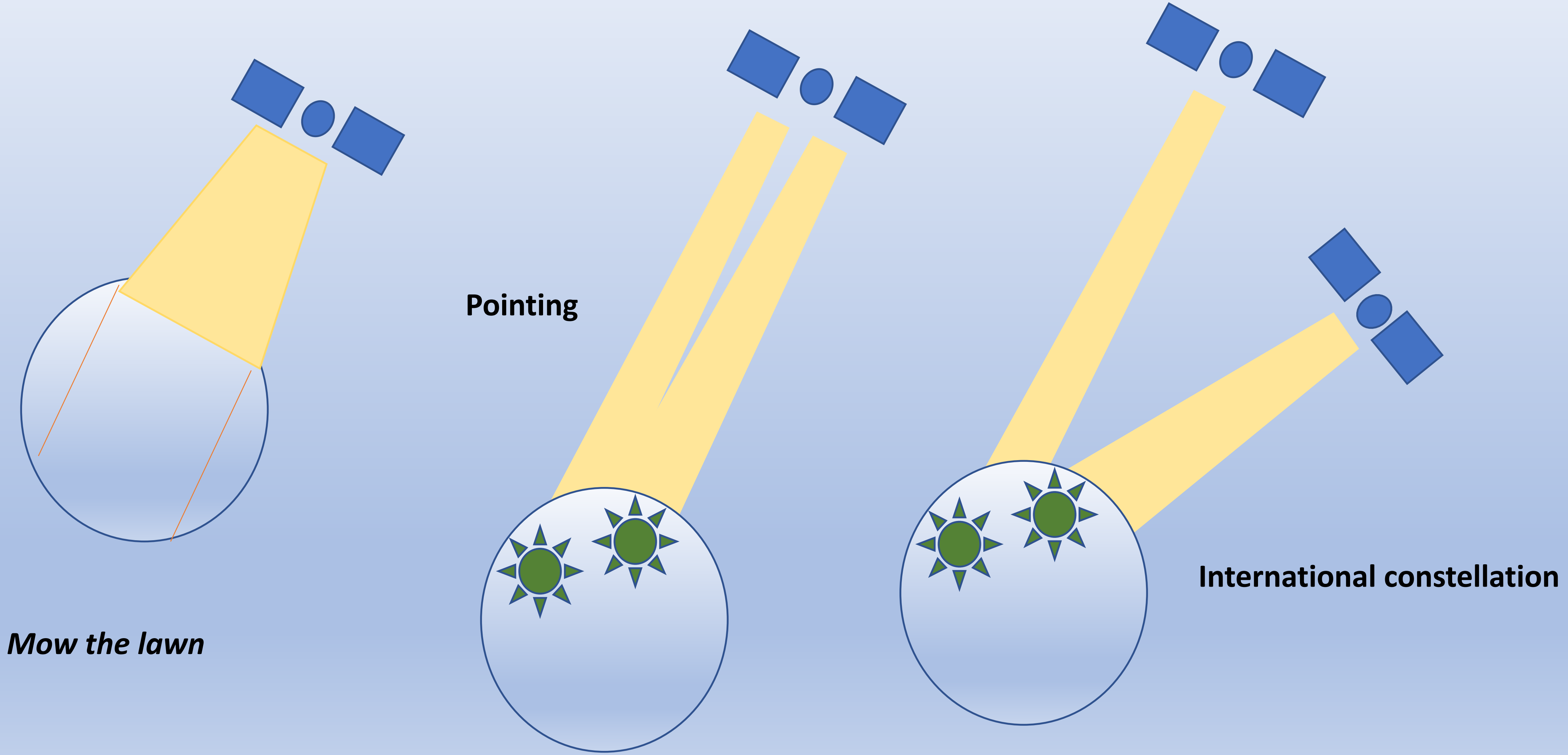
Primary Mission Challenge

- Plant traits
- Evapotranspiration
- Minerals
- Aquatic biology and biogeochemistry
- Snow
- Fire
- Volcanic gases
- Natural Hazards

Traditional Instrument Performance Metrics
Spectral range, resolution, SnR, etc

Space-time sampling and agility, constellations

End-member sampling strategies: *Mow The Lawn* versus *Pointing*



Observing Strategies depend on Focus Area

• Plant traits	Spectral performance
• Evapotranspiration	Temperature versus emissivity, frequency
• Minerals	Spectral performance
• Aquatic biology	Spectral performance, frequency
• Snow	Frequency
• Fire	Frequency, 4 micron dynamic range
• Volcanic gases	Frequency
• Natural Hazards	Frequency

Mow the lawn

Both

+Pointing

SBG Objectives

Distillation of Capability Class A Measurement Targets from SATM

VSWIR	
Spectral Range	0.25-0.4 to 2.5 μm
Spectral Resolution	~5-15 nm
SNR	VNIR: >400 SWIR: >250
Spatial resolution	30-45 m
Revisit	8-16 days +Events
Coverage	GLOBAL
Local time for acquisition	From 10:30 am to 1:30 pm

TIR	
Spectral Range	8 to 12 μm; 3-5 μm for Fires
Spectral Bands	Multiple (>4)
SNR	NeDT < 0.2
Spatial resolution	60-100 m
Revisit	Weekly + Events
Coverage	GLOBAL
Local time for acquisition	Can vary

Advances in technology lead to multiple options exist for meeting these targets

Resolving VSWIR and TIR Instrument Performance Targets

- All science areas emphasize demanding instrument performance targets.
- Substantial range of temporal sampling objectives between questions (sub-weekly-one time only).
- All science objectives need regular global repeat coverage sustained as long as feasible, some require also event-driven sampling.
- Societal benefits areas tend towards high time frequency and/or event oriented pointing.
- Considerable trade space exists around implementing time-space sampling, less around instrument performance.

Take-Home Points

- All SBG Observables require high instrument performance
  - Subtleties of instrument performance within the overall objectives space may matter - > Phase 3

- The ESAS “change” theme suggests “bonus” value for observing system architectures that last >3 years

- The change theme motivates
  - Measurement stability,
  - Cal/val oriented implementation
  - Consistent (eg sun-synchronous) sampling

- The ESAS societal benefit event role suggests “bonus” value for architectures that provide a consistent, long-term capability for users
  - Other societal benefits accrue from a single global map (eg, minerals).

Your Feedback Is Critical to SBG Success

- Each day will end with a report-out of key inputs.
- Late jet-lag thoughts or inspiration at 2 AM or the week after by email!
- Send to sbg@jpl.nasa.gov or DS, any co-lead.
- SBG website-SATM, working group reports, architecture reports will be posted.
- Our doors (virtual and physical) are open: contact D. Schimel, BE Middleton, J Luvall or working group co-leads as appropriate with ideas, interest, concerns.